Structura of ripe seed of wild diploid representatives of *Gossypium L.*

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Abstract. In the literature of past years, a large arsenal of knowledge about cotton has been accumulated. Much attention is paid to the study of the anatomical structure of the generative organs of cotton, which are of great scientific and practical importance. In modern breeding, wild species are often used by the parents of promising varieties, since they have very valuable biological properties for breeding. In modern literature there are works devoted to the study of correlations between the anatomical features of generative organs and biologically valuable features. The development of the seed coat of most species of the genus Gossypium L. has not yet been studied; therefore, it is relevant to conduct research on wild representatives of diploid species. The research results will significantly supplement the characteristics of the studied taxa and will serve as material in solving controversial issues of their taxonomy and phylogeny, as well as practical problems of breeding. We also determined the signs of hardness of the seed coat of the studied species, which correlate with early maturity. The level of advancement and the systematic position of certain species of the genus Gossypium L. were clarified.Analysis of all studied species established a correlation between the structural parameters of the seed and its rapid maturation in such species as wild African species G. barbosanum and G. soudanense, American G. trilobum and G. thurberi and both Australian species that can serve as starting material for modern breeding.

1 Introduction

Agricultural progress is the key to the growth and prosperity of the state, and high-quality seeds of promising varieties are the key to the progress of not only agriculture, but also the textile industry [1]. Cotton is a typical woody perennial shrub. As such, its flowering structures are sympodial axillary branches. The plant produces both vegetative and flowering structures throughout the productive season. The vegetative axis is composed of a tap root and vertical stem with alternate leaves, with a 3/8 turn, which continues to produce nodes as long as moisture and temperature allow. Flowering branches are sympodial and arise from the first (and sometimes second) axillary branch position at leaves above about

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the fifth node on the stem. Flowers develop with three floral bracts, a calyx whorl, five petals, and a 4- or 5-locule capsule in which six to nine ovules develop. Cotton fibers are unicellular trichomes that differentiate from the ovule epidermal cells. Cotton fiber development is divided into four different, but partially overlapping stages: initiation, elongation, secondary cell wall (SCW) biosynthesis, and maturation. Seeds require 35 to 60 d to mature. The epidermis of the seed develops two types of fibers: short (5 mm or less) linters and long (25–35 mm.) lint fibers.[2] The relationships between fiber quality characteristics and agronomic factors have been studied [3,4]. There has also been research into how genetic variations in cell size can affect fiber quality [5]. Scientists such as David D. Fang, Marina Naoumkina, Hee Jin Kim reviewed the progress in elucidating the mechanisms of fiber development based on the analysis of fiber mutants and summarized the genes and mechanisms that are critical for fiber development. [6]

J. Cliff Boykin argues that in addition to the flaws in the structure of the ginner and inadequacies in establishing a certain moisture content, there are other possible sources of SCF (seed coat fragment) formation, including cotton harvesters or pneumatic conveying systems in ginners. He also believes that better cotton varieties are need to produce more SCF-resistant seeds. [7]

Grabovets N.V. it was found that the presence or absence of an air cavity in the peel of cotton seeds is a diagnostic significant sign. Also, the larger the size of the air cavity, the more advanced the representative. The smaller the difference in the size of the thickness of the peel of the mature seed in the middle part and the chalaza, the harder the peel of the seed, therefore, the degree of contamination of the cotton fiber by the peel will be higher. In particular, the higher the index of the ratio of the size of the seed and the air cavity, the more days during germination. [8]

As you know, the function of the seed coat is to protect against damage, overdrying and premature germination. A trait such as the hardness (or strength) of the peel plays a role in separating the fiber from the cotton seed. [9] Reduced seed hardness leads to fiber clogging when ginning raw cotton [10, 11]. The dependence of the growing season on the thickness of the ripe seed peel has been revealed. Fiber impurity also depends on the hardness of the ripe seed skin. And the hardness, in turn, depends on the thickness of the walls and on the height of the cells of the external integument, as well as on the height and content of the cells of the external epidermis of the internal integument (NEVI) of the seed coat. [8].

Based on the foregoing, we studied the structure of the peel of mature seeds of wild diploid species of Africa, America and Australia.

2 Methods and materials

Experimental studies were carried out under the conditions of allotment experiments and on the photoperiodic site of the laboratory of systematics and introduction of cotton of the Institute of Genetics and Experimental Biology of Plants, ANRUz. For anatomical analysis, mature seeds were fixed (in 70% ethanol). Measurements were carried out and preparations were made of cross sections of mature seeds in the middle and chalazal parts. The collected material was morphometrically processed, photos were taken, tables were compiled.

Anatomical studies were performed according to the accepted methods [12, 13, 14, 15, 16, 17]. During the research, a trinocular microscope XSP-500SM (7-inch screen with the ability to connect to a PC), a measuring device MOV-15 and a portable digital microscope UM039 were used.

The objects of the study are wild diploid species of the Old World G.anomalum, G.barbosanum, G.stocksii, G.incanum, G.soudanense; of the New World G.raimondii, G.trilobum, G.thurberii, G.klotzschianum, G.harknessii and of Australia G.bickii, G.australe

3 Discussion

Comparing the studied G. raimondii, G. trilobum, G. thurberii, G. klotzschianum, G. harknessii in the first week of development, higher indicators of the structure of characters OI, OEII and total thickness were noted in G. thurberii. (see table 1) In adulthood, these indicators are higher in G. trilobum (OI), G. klotzschianum (OEII), and the total thickness of the seed coat is higher again in G. thurberii. (see table 4) The thickness of PII in adulthood does not show significant differences in all species, as well as in the number of cell rows in a given tissue. They are from 4 to 6 in all species. The greatest thickness of PII reaches in all species at 2 weeks of age. (see Figure 3) G. harknessii reaches the highest height of PII tissue cells at 4 weeks of age, the rest at 2–3 weeks of age. It should also be noted that this layer in the peel of a mature seed decreases 1.2-2.4 times, with the exception of G. trilobum. His POI in the process of formation increases by 1.1 times. And the cells themselves, when the seed ripens, in all representatives are extended in the tangential direction. OEOI in all species has higher rates at all stages of development than POI and IEII, with the exception of G. klotzschianum and G. harknessii. POI in all species consists of 2-3 rows of cells. NI occupies a much smaller volume in percentage terms and linear indicators are lower than II. (see figure 2) More significant changes take place in II than in OI due to the intensive growth of OEII and PII. During maturation, OEII cells in all studied species elongate rather strongly in the radial direction. So at the initial stage, their height is 12.1-28.5 microns, then by 3 weeks this layer increases 2.3-5.7 times in G. thurberii and G. raimondii, by 4 weeks - in 7.9-10.2 - in G. trilobum and G. harknessii, and by 11.3 times to maturity - in G. klotzschianum. Moreover, G. thurberii had a great height at 1 week of age, and G. klotzschianum at mature age. The percentage of this layer increases before maturation in all species from 1-4% to 39-52%. The multilayered PII in all species, both at the initial stage and in adulthood, has a similar number of cells. By the age of 2 weeks, the number of rows becomes maximum, and then the destruction of cells in the lower rows of this layer occurs, which leads to a sharp decrease in the height of PII, II and the total thickness. In G. raimondii and G. klotzschianum, PII decreases by 15.6 and 14.1 times, in G. thurberii and G. harknessii by 6.2 and 7.8 times, and in G. trilobum by 10 times. The volume of PII occupied in the spermoderm at 1 week of age in all studied species is 79-82% and in mature - 18-29%, with the maximum volume of PII in adulthood in G. harknessii, and the minimum in G. klotzschianum, in which At 1 week of age, the highest percentage of PII occupied in the integument.

IEII in all studied species practically does not undergo any changes during formation. IEII increases by 1.5-2 times and it reaches its maximum height by 2 weeks in G. raimondii, G. trilobum, G. klotzschianum, with a greater height in G. trilobum. Then the epidermis is reduced by 1.1-1.4 times at 4 weeks of age, it is no longer there.

With the exception of G. klotzschianum, its epidermis is no longer observed at 3 weeks of age. In the rest, IEII increases by 1.8-2.4 times up to 3 weeks, and by the 4th it is not observed. In percentage terms, IEII in all studied species is 1-4%.

Table 1. The thickness of individual layers of integuments of different-aged ovules and peel of mature seeds in wild representatives of USA, μm, n = 10.

wild species	Age per week	outer integument				inner integument				Σ
		OE	P	IE	Σ	OE	P	IE	Σ	
G. *raimondii*	1	19,7±1,7	24,8±2,3	13,0±1,0	57,5±5,5	17,6±1,5	375,9±38,9	10,2±1,9	403,7±36,2	461,2±46,3
	2	39,4±3,5	47,4±4,8	13,9±1,2	100,7±10,5	90,5±9,5	659,8±69,5	21,2±1,9	771,5±79,4	872,2±85,6
	3	41,4±3,	47,4±4,	13,1±1,	101,9±	100,0±	501,5±	20,4±2,	621,9±6	723,8±76,

		9	9	2	11,2	11,6	54,2	1	5,2	8
	4	40,5±3,8	32,4±3,6	11,7±1,1	84,6±8,9	94,9±9,8	246,0±25,4	-	340,9±33,1	424,1±43,5
	m.	34,3±3,1	20,4±2,3	10,9±1,2	65,6±5,8	89,1±8,7	42,3±4,3	-	131,4±12,8	197,0±17,3
G. *trilobum*	1	23,3±2,5	21,9±2,0	10,9±1,0	56,1±5,8	22,6±2,6	402,2±41,6	10,2±0,5	435,7±45,3	491,1±48,6
	2	48,2±5,1	42,3±4,3	13,6±1,1	104,1±11,9	105,8±11,5	562,7±55,2	21,9±2,4	690,4±68,7	794,5±81,2
	3	69,3±6,8	35,7±3,5	13,8±1,2	118,8±12,0	118,8±12,3	268,6±27,3	15,3±1,5	400,5±36,9	525,5±53,6
	4	72,2±7,5	33,6±3,2	14,6±1,4	178,6±18,5	178,6±16,0	167,9±19,3	-	289,8±29,4	410,2±45,3
	m.	59,8±5,9	24,8±2,6	19,7±2,1	104,3±9,8	104,3±9,8	56,2±5,2	-	174,4±15,3	278,4±25,4
G.*thurberi*	1	27,5±2,6	32,1±3,6	12,4±1,3	71,5±7,4	28,5±2,9	381,0±39,1	12,4±1,2	421,9±41,9	493,4±51,2
	2	65,0±6,5	35,8±3,2	13,5±1,5	114,3±12,6	110,2±14,3	408,0±43,4	21,2±2,4	529,4±50,7	653,7±66,2
	3	65,4±6,4	34,3±3,3	14,6±1,6	114,3±14,0	121,9±12,1	291,9±31,0	21,9±1,7	435,7±40,9	554,7±54,2
	4	65,7±6,2	33,6±3,0	17,5±1,8	116,8±15,2	121,4±10,9	167,9±18,2	-	289,3±29,1	406,1±41,3
	m.	63,5±6,1	22,5±2,4	17,5±1,3	103,5±11,4	121,2±10,1	65,7±5,4	-	186,9±18,3	290,5±25,6
G. *klotzschianum*	1	15,3±1,3	16,8±1,5	12,0±1,5	44,1±4,6	12,1±10,6	330,0±32,0	14,3±1,	342,7±34,2	386,5±35,9
	2	33,6±3,5	32,5±3,5	12,4±1,6	78,5±7,0	112,4±14,2	585,4±55,2	21,9±2,1	719,7±73,6	798,2±73,6
	3	40,8±3,9	47,4±4,6	12,4±1,2	100,6±10,6	123,[illegible]±8,0	295,5±24,1	-	378,8±35,6	479,4±48,6
	4	40,9±4,1	37,9±3,8	12,4±1,6	91,2±9,5	129,9±15,1	232,8±20,1	-	362,7±37,0	453,9±49,2
	m.	45,2±4,6	12,4±1,1	11,7±1,3	69,3±6,1	136,5±14,1	41,5±4,2	-	178,0±16,0	250,4±22,8
G. *harknessii*	1	19,3±1,8	28,5±2,8	12,1±1,3	59,9±6,0	13,9±2,6	408,5±28,1	8,9±0,4	431,5±42,3	491,4±52,3
	2	26,5±2,5	38,3±3,9	12,4±1,1	77,2±7,2	111,7±12,9	537,9±56,4	20,4±2,1,6	670,0±65,2	747,2±76,5
	3	27,0±2,4	48,2±4,5	12,4±1,0	83,7±9,8	131,4±10,9	389,0±41,2	21,2±2,3,5	541,5±52,3	629,2±66,2
	4	35,8±3,3	49,9±4,7	12,4±1,3	99,1±9,3	141,6±13,5	235,0±25,1	-	376,6±36,7	473,7±46,3
	m.	28,5±2,9	31,7±1,0	10,8±1,1	51,0±4,9	127,7±13,4	69,3±7,1	-	197,0±20,6	248,0±21,6

4 Wild diploid species of Africa

Comparative analysis of wild diploid African species showed that in all studied representatives the total integument thickness reaches its maximum value already at 2 weeks of age. The greatest thickness at this age is in G. soudanense, the smallest in G. incanum. (see table 2) Then the process of destruction of PII cells begins. The maximum PII thickness by 2 weeks is observed in G. soudanense, the number of cell layers is 22-24, in the rest - 13-20. IEII is not observed at the same age. (see figure 3) The percentage of OI and II in all studied species varies in different ways. (see figure 2) Moreover, at all stages of development, II has a higher percentage than OI. In G. barbosanum and G. soudanense, the percentage of II at the age from 1 to 2 weeks increases from 74 to 87%, and by maturity it decreases to 77%. For the rest, the percentage decreases in the period from 1 week of age to 4 weeks from 85-89% to 72-78%, and by maturity it increases to 78-83%. This high II is due to the high% PII. It should also be said that by adulthood all tissues OI and II have the maximum size of G. soudanense. G. stoksii has the greatest height of OEII and OEOI to maturity. The biggest changes are happening in the OEII. Its cells elongate in the radial direction and reach their maximum size in adulthood, and the highest rate of cell growth in all representatives occurs in the period from 1 to 2 weeks. And the maximum speed during this period among the studied species was in G. soudanense. In all studied species, POI consists of 2-3 rows of cells, in the process of development, elongated in the tangential direction. In the process of maturation, all tissues of the spermoderm undergo various changes. The cells of both epidermis OI increase 1.8-2.8 times at different stages of

development, and by maturity these cells decrease somewhat. An exception is G. soudanense, his OEOI increases until adulthood. OEII in adulthood occupies a larger volume in all species than in other tissues (53-71%). Moreover, at 1 week of age, it takes 1-6%.

5 Wild diploid species of Australia

Analysis of integuments of different-aged ovules and peel of mature seeds of wild species revealed some differences in their growth rates and indicators of structural features in the process of seed formation. (see table 3)

The thickness values of OEOI in one-week old ovules of both species are similar. The growth rate of OEOI cells in the first week in G. bickii is 17.6 μm per day, in G. australe there are no changes. The growth of cells of this layer in all studied representatives lasts up to 4 weeks. In the peel of mature seeds, there are taller epidermal cells in G. bickii.

Table 2. The thickness of individual layers of integuments of different-aged ovules and peel of mature seeds in wild representatives of Africa, μm, n = 10.

wild species	Age per week	outer integument				inner integument				Σ
		OE	P	IE	Σ	OE	P	IE	Σ	
G.anomalum	1	17,9±1,5	21,8±2,0	10,9±1,1	50,6±4,9	17,9±1,5	390,0±37,9	12,5±1,1	420,4±41,9	471,1±45,8
	2	51,5±4,3	35,1±3,2	16,4±1,5	103,0±11,2	136,4±13,5	689,5±69,8	-	815,8±82,2	918,8±93,4
	3	49,9±4,6	53,0±5,2	14,8±1,6	117,7±12,0	132,0±12,8	471,9±48,1	-	603,9±61,4	713,8±74,2
	4	36,3±4,1	26,7±2,5	13,3±1,2	76,3±7,5	138,3±14,0	72,4±7,4	-	201,0±21,0	286,3±25,6
	m.	29,5±2,4	23,5±2,2	9,3±0,9	62,3±5,4	145,7±15,1	68,8±6,5	-	214,5±22,4	279,6±22,4
G. barbosanum	1	15,7±1,6	28,5±2,5	10,1±1,0	54,3±5,2	14,5±1,1	316,1±34,2	14,6±1,3	345,2±35,0	399,5±40,1
	2	28,6±2,8	34,4±3,5	15,5±1,6	78,5±7,2	161,4±12,6	554,0±56,1	-	715,4±75,0	793,9±81,2
	3	36,5±3,5	29,7±3,0	21,1±2,0	86,9±8,5	165,4±14,7	222,6±20,0	-	388,0±35,2	474,9±45,6
	4	35,7±3,6	23,4±2,5	15,3±1,3	74,4±7,0	169,3±15,2	79,6±7,5	-	248,9±25,8	323,3±35,0
	m.	31,1±3,1	19,0±1,5	13,1±1,2	63,2±6,4	172,3±18,7	44,5±4,2	-	216,8±22,5	280,0±27,9
G. stocksii	1	26,0±2,5	17,1±1,6	9,0±1,0	52,1±5,1	22,0±1,9	311,2±34,1	7,8±0,9	341,0±35,4	393,7±41,2
	2	57,7±5,5	34,3±3,3	11,7±1,1	103,7±12,0	226,2±24,8	486,7±45,9	-	712,9±72,4	853,3±85,0
	3	64,0±6,4	35,1±3,5	11,7±1,4	110,8±11,8	239,4±23,4	238,7±24,7	-	478,1±45,6	587,3±57,9
	4	66,3±6,3	43,7±4,4	12,5±1,4	122,5±14,2	249,6±25,0	195,0±20,4	-	444,6±46,1	566,3±55,3
	m.	42,9±3,8	9,4±0,8	10,9±1,1	63,2±6,6	255,1±24,3	45,2±4,7	-	300,3±29,5	362,7±32,2
G. incanum	1	16,1±1,5	22,3±2,1	9,6±0,9	48,0±4,6	16,1±1,5	248,3±21,8	8,1±0,7	272,5±29,4	308,1±31,4
	2	33,5±3,2	33,5±3,3	14,8±1,1	81,8±7,9	138,8±12,9	283,6±25,7	-	622,4±65,1	730,1±75,1
	3	45,2±4,6	45,2±4,3	15,6±1,6	85,8±8,6	166,1±15,8	262,1±28,6	-	428,2±41,8	542,9±55,6
	4	46,8±4,7	46,8±4,5	7,0±0,8	69,4±7,0	160,7±17,0	129,5±14,0	-	290,2±30,0	357,2±32,4
	m.	28,5±2,5	14,0±1,3	5,6±0,9	48,1±3,7	142,3±17,4	28,5±2,9	-	170,8±18,1	217,3±11,7
G. soudanense	1	16,4±1,5	27,9±2,2	9,0±0,8	53,3±5,2	7,8±0,9	132,4±14,6	7,5±0,8	140,2±12,8	193,5±20,4
	2	33,0±3,0	33,0±3,1	45,0±4,5	111,0±10,9	159,0±14,9	778,5±78,5	-	937,5±95,1	1045,5±108,9
	3	34,5±3,5	37,1±3,5	53,2±5,6	124,8±15,0	167,3±17,8	539,9±56,0	-	707,2±71,4	832,0±85,7
	4	36,0±3,2	33,0±3,5	61,5±6,1	130,5±13,7	181,5±19,2	301,5±31,0	-	483,0±45,9	613,5±65,3

	m.	36,7±3,7	32,8±3,4	16,4±1,4	85,9±9,1	215,3±21,6	73,3±7,2	-	288,6±28,4	374,5±33,6

In percentage terms, this layer occupies 5-7% in the first week and 11-12% in the peel of mature seeds. (see Figure 2) In the studied species, the POI consists of 2-3 rows of cells. Among the two species, a thinner parenchyma - 15.7 μm in the integument of a one-week old ovule - was noted in G. australe. In G. bickii, this layer reaches its maximum size in the first week. (see figure 3) Further, OEOI cells begin to flatten and stretch in the tangential direction. And by the end of seed formation, the POI height decreases 2.8 times. In G. australe, it reaches its maximum size by 4 weeks, and decreases by 1.3 times by maturity. The percentage ratio of POI to total thickness during development in G. bickii decreases from 11% to 8%, and in G. australe it increases from 6% to 10%. The height of IEOI cells at one week of age is higher in G. bickii - 11.6 μm. The growth rate from 1-2 weeks in G. bickii is 0.2 μm per day, in G. australe - 0.1 μm. IEOI cells increase in height up to 2 weeks in G. bickii, and up to maturity in G. australe. In percentage terms, IEOI occupies less volume at all stages of development than other tissues.

In the height of the palisade layer cells (OEII), the studied species have significant differences at all stages of formation. The increase in the cells of the palisade layer lasts up to 4 weeks, reaches the greatest size, especially in G. bickii. The growth rate of cells in the first weeks is different in G. bickii — 11.1 μm per day, and in G. australe — 7.4 μm. In the studied Australian species during maturation, the OEII volume increases from 3-4% to 50-55%.

In the height of the palisade layer cells (OEII), the studied species have significant differences at all stages of formation. The increase in the cells of the palisade layer lasts up to 4 weeks. In G. bickii, PII increases by 1.9 times, and in G. australe by 2.5 times. Further, the process of cell destruction (destruction) begins and PII decreases to maturity in G. bickii to 27.0 μm, and in G. australe to 21.1 μm. In the process of formation in all species, there is a decrease in the volume of PII from the total thickness of the spermoderm from 73-75% to 16-18%.

IEII differs from other layers in much smaller size and development rate. The greatest thickness of IEII at the initial stage is in G. bickii, and the speed is higher - 0.7 μm per day. In both species, this layer increases up to 3 weeks, and then it collapses, and by 4 weeks it is absent. Also, in the studied species, the volume occupied by IEII at all stages of development is the smallest.

As a result of the data obtained, significant differences were established between the species of the Old, New World and Australia, according to 6 anatomical features. Since G. soudanense is a controversial species, the following differences from African species have been identified. This type is distinguished by a greater thickness of OI, IEOI and OEII. The total thickness (G. stoksii), PII (G. anomalum), OEOI (G. anomalum, G. barbosanum) do not differ significantly from G. soudanense.

A comparative analysis of the structure of the peel of mature seeds of diploid species also revealed significant differences in the linear data of structural features. The wild species G. raimondii is reliably from all American species studied in three dimensions: total thickness, OEOI and OEII. For the other three indicators (OI, IEOI, PII) G. raimondii significantly differs from G. trilobum, G. thurberi, and G. harknessii - OI and PII.

Correlation analysis of the results revealed an inverse relationship in all studied wild species of the Old, New World between early maturation and the total thickness of the peel of a mature seed (see Figure 1)

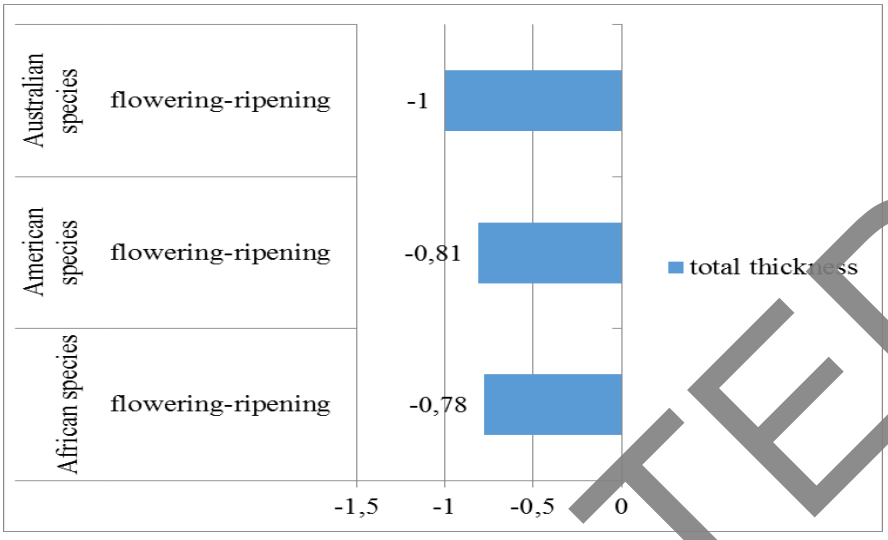

Fig. 1 Correlation series of wild diploid cotton species.

Table 3. The thickness of individual layers of integuments of different-aged ovules and peel of mature seeds in wild representatives of Australian, μm, n = 10.

wild species	Age per week	outer integument				inner integument				Σ
		OE	P	IE	Σ	OE	P	IE	Σ	
G.*bickii*	1	14,3±1,2	31,7±3,0	11,6±1,2	57,6±5,5	71,6±1,4	214,0±22,0	9,5±0,9	285,1±29,5	292,8±30,4
	2	19,7±2,0	20,1±2,0	16,8±1,5	56,9±5,8	89,8±8,9	400,0±41,0	14,6±1,5	504,4±51,9	561,3±55,3
	3	20,4±2,4	16,1±1,5	16,3±1,7	52,6±5,4	100,0±11,1	121,9±11,8	16,1±1,7	238,0±24,8	290,6±34,2
	4	21,1±2,4	17,3±1,8	16,8±1,6	55,4±5,0	100,7±12,0	73,7±7,2	-	174,5±18,1	236,5±25,9
	m.	19,5±1,1	11,2±1,0	13,1±1,2	43,9±5,1	93,5±8,7	27,0±2,8	-	120,5±13,7	164,4±17,3
G. *australe*	1	14,5±1,4	15,7±1,5	8,9±0,9	39,1±4,0	9,5±0,6	167,7±15,8	6,8±0,6	184,0±19,5	223,1±27,3
	2	14,5±1,2	14,8±1,6	9,2±0,7	38,5±3,5	61,9±6,2	417,5±42,0	8,0±0,8	487,4±45,6	525,9±55,4
	3	14,0±1,3	16,9±1,2	9,3±1,0	40,8±4,2	63,7±6,7	245,1±25,4	9,3±1,0	318,1±30,7	358,9±38,1
	4	14,8±1,5	19,0±2,0	9,5±0,9	43,3±4,3	65,6±6,6	72,7±6,8	-	138,3±14,5	181,6±17,5
	m.	14,6±1,5	12,2±1,1	10,4±1,1	37,2±3,8	62,6±6,3	21,1±1,9	-	83,7±8,5	120,9±11,6

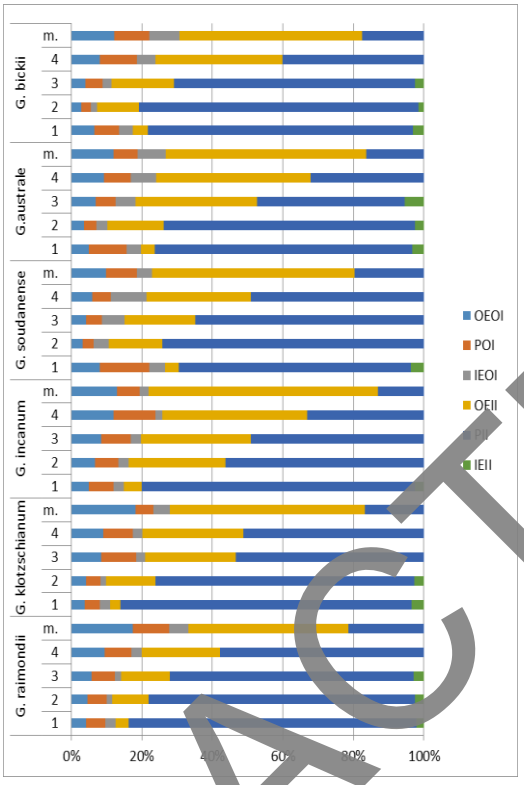

Fig. 2 The percentage of cotton spermoderm tissues during development.

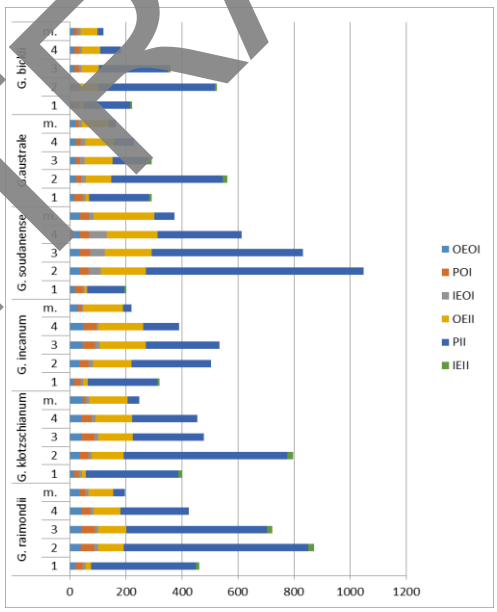

Fig 3 The ratio of cotton spermoderm tissues during development.

6 Conclusion

6.1 Wild growing diploid American species

Many wild cotton species are narrow and very narrow endemics. They are all concentrated in a small area in the region of northwestern Mexico including the Baja California Peninsula and its neighboring islands, with the exception of the species G. *klotzschianum* in the Galapagos Islands, G. raimondii in northwestern Peru (foothills of the Andes). The species of this group are distinguished by strong growth and high polymorphism in many morphological characters. Among them there are species with very valuable traits and biological properties for practical breeding: frost-resistant (G. *trilobum*), salt-resistant (G. *klotzschianum*) and a number of others. We studied the structure, development and rate of formation of spermoderm of wild diploid species of the New World - G. *raimondii*, G. *trilobum*, G. *thurberii*, G. *klotzschianum*, G. *harknessii*.

At comparison of studied American species (2n = 26) between them in the first week of development and in adulthood marked higher rates of structural signs of OI,OEII and the total thickness of *G.thurberi* species (see Table 4). PII thickness in acme of all species has no significant differences as well as the number of rows of cells in the given tissue. They are from 4 to 6 in all species. The greatest thickness PII reaches in all species in 2 weeks. OI occupies a much smaller volume in percentage and linear rates are lower than II. In II occur more significant alterations than in OI, due to the intensive growth of the OEII and PII. From the percentage OEII increases in all species from 1-4% to 39-52%. OEII in all studied species in the formation process virtually does not undergo to changes (see Figure 4).

6.2 Wild diploid African species

Most species of the group are low, sometimes very small shrubs with a thin flexible stem, thin branches, small flowers and seeds. They are disturb only in the Paleotropic region, live in the wild in the zones of Savana, the coastal deserts of the peninsulas. Among this group there are a large number of species that are very valuable for practical breeding: ultra-early ripening (Guza iz Turfan), very fertile (G. stoksii), strong and delicate fiber (G. anomalum)

Comparative analysis of wild diploid African species showed that in all studied representatives total thickness of integuments reaches its maximal value already in 2 weeks. Maximal thickness in this age in *G. soudanense* species, the least in G. *incanum* species. Then process of destruction of PII cells will begin. Maximal thickness of PII to the 2 week is observed in G. *soudanense* species, number of cell layers - 22-24, in others 13-20. At the same age IEII is not observed. The greatest alterations occur in the OEII. Its cells are extended in the radial direction and reach their maximal size in acme, with the highest rate of cells' growth in all members takes place from 1 till 2 weeks. *G. soudanense* has the maximal rate during this period among the studied species. In all studied species POI of given group consists of 2-3 rows of cells that in the process of development are extended in the tangential direction.

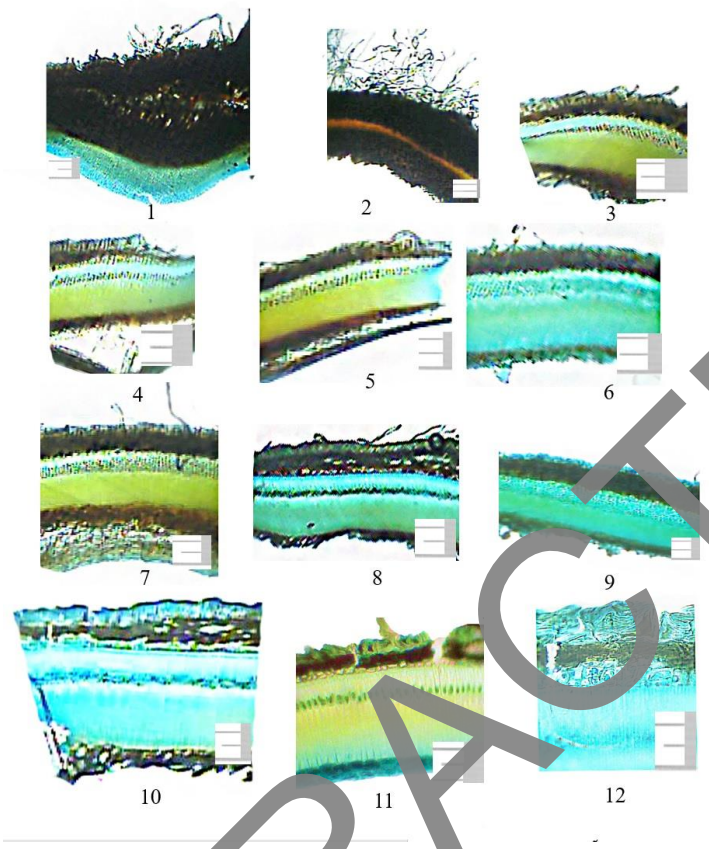

Fig. 4 The peel of a mature seed in wild diploid species of the genus of Gossypium L.: 1 - *G.anomalum;* 2 - *G.barbosanum;* 3 - *G.stocksii;* 4 - *G.incanum;* 5 - *G.soudanense;* 6 - *G.raimondii;* 7 - *G.trilobum;* 8 - *G.thurberii* 9 - *G.klotzschianum;* 10 - *G.harknessii;* 11 - *G.bickii;* 12 - *G.australe*

Table 4. Quantitative indicators of the structural signs of ripe seed integuments of wild diploid representatives of genus Gossypium L. n = 10.

wild species	∑, µm	OI		OEOI, µm	IEOI, µm	OEII		PII	
		µm	%			µm	%	µm	%
G.raimondii	197,0 ± 17,3*	65,6 ± 5,8*	34	34,3 ± 3,1*	10,9 ± 1,2*	89,1 ± 8,7*	45	42,3 ± 4,3	21
G.trilobum	278,4 ± 25,4	104,3 ± 9,8	30	59,8 ± 5,9	19,7 ± 2,1	104,3 ± 9,8	39	56,2 ± 5,2	21
G.thurberi	290,5 ± 23,6	103,5 ± 11,4	36	63,5 ± 6,1	17,5 ± 1,3	121,2 ± 10,1	42	65,7 ± 5,4	22
G.klotzschianum	250,4 ± 22,8	69,3 ± 6,1	28	45,2 ± 4,6	11,7 ± 1,3	136,5 ± 14,1	55	41,5 ± 4,2	17
G.harknessii	248,0 ± 21,6	51,0 ± 4,9	19	28,5 ± 2,9	10,8 ± 1,1	127,7 ± 13,4	52	69,3 ± 7,1	28
G.bickii	164,4 ± 17,3*	43,9 ± 5,1	27	19,6 ± 1,1*	13,1 ± 1,2*	93,5 ± 8,7*	57	27,0 ± 2,8	16
G.australe	120,9 ± 11,6	37,2 ± 3,8	31	14,6 ± 1,5	10,4 ± 1,1	62,6 ± 6,3	52	21,1 ± 2,9	17
G.anomalum	279,6 ± 22,4	62,1 ± 5,4	22	29,5 ± 2,4	9,3 ± 0,9	145,7 ± 15,1	53	60,8 ± 6,5	25
G.incanum	217,3 ± 11,7*	48,1 ± 3,7*	22	28,5 ± 2,5*	5,6 ± 0,9*	142,3 ± 17,4*	65	28,5 ± 2,9*	13
G.stocksii	362,7 ± 32,2	63,2 ± 6,6	18	42,9 ± 3,8	10,9 ± 1,1	255,1 ± 24,3	70	45,2 ± 4,7	12
G.barbasanum	280,0 ± 27,9	63,2 ± 6,4	23	31,1 ± 3,1	13,1 ± 1,2	172,3 ± 18,7	61	44,5 ± 4,2	16
G.soudanense	374,5 ± 33,6	85,5 ± 9,1	23	36,7 ± 3,7	10,4 ± 1,4	215,3 ± 21,6	57	73,3 ± 7,2	20

Note: ∑- total peel thickness
Underlined representatives compared with each other on studied marks
*- existence of significant differences between readings of the compared representatives.

6.3 Wild diploid Australian species

They are distributed mainly in the arid semi-desert and desert areas of Northwest, Western and Central Australia. These species, although characterized by no less polymorphism than the species of the New World, have only their inherent morphological and biological characteristics and properties. Among the species of this group there are those valuable for practical breeding, ultra-early maturing, weakly reacting to the photoperiod (G. bickii, G. australe). Analysis of integuments of uneven-aged ovules and peel of ripe seeds of wild species of Australia — *G.bickii* and *G.australe* revealed some differences between the rate of their growth rates and structural signs in the formation of the seed.

Readings of OEOI thickness in one-week old ovules of both species are similar. In the studied species POI consists of 2-3 rows of cells. Between the two species thinner parenchyma -15.7 µm in the ovule integument of one week was observed in G.*australe* species. In G.*bickii* species given layer in this age reaches its maximal size. Further OEOI cells begin to flatten and stretch in the tangential direction. By the end of seed formation POI height is reduced by 2.8 times. Augmentation of palisade layer cells lasts up to 4 weeks. At the height of the palisade layer cells (OEII) studied species have significant differences at all stages of formation. Augmentation of the palisade layer cells lasts up to 4 weeks. IEII differs significantly from other layers of smaller size and rate of development.

As a result of comparative analysis of the obtained data revealed significant differences between species of the Old World, New World and Australia, on 6 anatomical marks. In the group of African species *G.soudanense* different from other by its thickness OI, OEII and OEII, for a total thickness of the peel seed (*G.stoksii*), PII (*G.anomalum*), OEOI (*G.anomalum, G.barbosanum*) have no significant difference with G.*soudanense* species.

Comparative analysis of the structure of ripe seed peel of wild growing American diploid species has revealed likewise significant differences of linear sizes of its structural

signs. So wild species *G.raimondii* reliably differs from other species on three marks: overall thickness, OEOI and OEII. On other three indicators (OI, IEOI, PII) *G.raimondii* reliably differs from *G.trilobum*, *G.thurberi* species, and on such signs as the height of OI and PII – from species *G.harknessii.* Obtained results reveal the trueness of isolation of this species to individual from others subsection.

Correlative analysis of results of study of the Old, New World and Australian wild species has revealed the inverse dependence between the total thickness of ripe seed peel and earliness.

In wild diploid species from different continents rate of development of integumental layers of the seed coat is higher. Data of studied breeds: on duration of the period from sowing to coming-up, seed size, quantitative readings of structural features of the peel make it possible to judge that such features as the thickness of chalaza and lateral surface of the seed peel and the width of the base of pneumatic cavities OI are playing a significant role in the predisposition to defect formation. Results of investigations of wild diploid species prove the primitiveness of the Old-world and advance of New World and Australian species. It was confirmed isolation of G. soudanense (African) and G. raimondii (US) species in a separate subsection. The readings of primitiveness are small-seediness, high thickness and density of the peel, conservativeness of structure, expressed in general plan of the structure of the seed peel.

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